Report for 2002NH2B: Dynamics of Groundwater Inflows to the Lamprey River, New Hampshire

There are no reported publications resulting from this project.

Report Follows:

Progress Report for

Dynamics of Groundwater Inflows to the Lamprey River, New Hampshire

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1.0 Problem Statement and Research Objectives

The Lamprey River Watershed is an important component of the water resources of the seacoast region of New Hampshire and is similar in climatology and hydrogeology to many watersheds in New England. The Lamprey serves as a water supply for municipalities including Deerfield, Raymond, Epping, and Newmarket, as well as serving as an auxiliary water supply for Durham and the University of New Hampshire. Current activities within the watershed, including a proposed bottled water plant near Northwood, may result in changes to the aquifer system. Forecasting and potentially mediating late-summer low flow conditions in the Lamprey (and other similar rivers in the region) are critical to effectively managing these resources. In addition to the Lamprey's importance as a water resource, an 11.5-mile stretch of the Lamprey River from Newmarket to Lee was declared a National Wild and Scenic River. With this declaration, several restrictions were initiated, including policies against new dam and water transfers; water quality; channel alterations; new solid-waste facilities; and protected in-stream flows. These restrictions protect both the stream and surrounding ecology from future effects of population growth in the region. An important factor in protecting stream ecology is the dynamics of the river during reduced flows.

During reduced flow periods, a large percentage of surface water flow is derived from groundwater inputs (Perkins and Sophocleous, 1999; Harvey and Bencala, 1993; Cey et al., 1998). However, little research has been conducted to quantify inputs to the Lamprey River discharge from sources such as stratified drift aquifers, bedrock aquifers, and springs. Previous work on low flow systems in New England (Dingman and Lawlor, 1995; Risley, 1994; Barnes, 1986; and Kliever, 1996) have focused on the statistical methods of determining low flows rather than the source of water during these periods.

The principal objective of this research is to test the hypothesis that the stream flow in the Lamprey River during the late summer to early fall is controlled by the gravity drainage of both the bedrock and stratified drift aquifers. Ideally, we would be able to quantify the relative amounts of water from sources such as stratified drift aquifers and bedrock aquifers to determine the temporal hydrologic controls of surface water. Over the past year, we have collected groundwater and surface water data and collated historical groundwater and surface water data to help determine relationships between the aquifer and stream systems. The research is on-going, and this document will describe work that has been completed to date and describe future work.

2.0 Research Methods

2.1 GIS Analysis

GIS databases were obtained from GRANIT to compile data from the Lamprey River Basin. Particular data layers of interest that will be used later in the modeling phase of this proposal (see Section 2.4 for further discussion on the model phase) include the hydrography layer, surficial material layer, and the DEM data layer. Data layers were merged for the watershed, and cut based on a layer that contained the watershed boundary. This will allow for the production of maps on the watershed for the final research paper for this proposal.

2.2 Groundwater Data

Groundwater data collection was undertaken in July of 2002 with the assistance of personnel from the New Hampshire Department of Environmental Service (NHDES). Wells from a 1984 survey on water resources that were not decommissioned or destroyed were located throughout the watershed. Two wells were installed with a data-logging system that recorded levels at hourly intervals, and 5 additional wells (including USGS monitoring wells located in Deerfield and Lee) were monitored on a weekly basis. The data will be used to calibrate and verify the groundwater model (see Section 2.4 for further discussion on the model).

All monitored wells were advanced into the stratified drift aquifer. No wells were located to be monitored within the bedrock aquifer. Therefore, incomplete data exists for the bedrock aquifer. However, this should not be an issue since the model being developed will assume that the initial piezometric surface is a representation of the DEM data file (topography).

We will continue to work with NHDES and the NHGS to identify strategic locations for additional long-term monitoring wells in both the stratified drift and bedrock aquifers.

2.3 Surface Water Data

Historical data was collected from the USGS gage located on the Lamprey River near Packers Falls. This data was analyzed with basic hydrologic models to determine basic properties of the aquifer and the stream. This was completed by isolating data from 10 years of the lowest recorded flow. This data was further isolated by collecting precipitation and weather data from both Epping and Concord for the same time period. By combining this data, 10 hydrographs were analyzed and fitted with mathematical models to arrive at basic properties of the system. This data will be used as initial input into the groundwater model.

During this brief study, we were unable to identify optimal paired cross sections for determining gaining or losing conditions during low flow. However, this remains a critically important measurement and we will continue to search for an appropriate pair of stations.

Watershed Model

Our initial hypothesis focused on the superposition of outflows in two lumped-parameter models with different time constants. While we continue to pursue this as a viable hypothesis, limited data in the bedrock system severely limits our ability to assess the characteristics of the bedrock aquifer.

We are also developing a spatially distributed model to account for the significant topographic variability and its relation to surface water discharge characteristics. The model will be a single layer subdivided into stratified drift and bedrock components. The initial water table will be a function of the topography. The surface of the model will be coded either as a hydrographic feature (from GIS coverage) or a drain cell with a drain elevation equal to the surface elevation. A small amount of recharge will be applied to the entire model surface and the sensitivity of the recharged will be evaluated.

Results from the transient simulation will be analyzed in two ways. First, a map of the fluxes to the drains will be made for each time step. This will help understand how the drainage of the Lamprey River Watershed evolves over the course of a May-Sept season. Second, the drain fluxes will be integrated along the reaches above the Packers Falls gaging station to compare how well this simple model matches observed stream flow patterns.

Modeling Specifications. Argus ONE will be to work with GIS layers to form grids that were readable into MODFLOW. The model will be built to run with MODFLOW96.

The following steps have been completed to set-up the model:

1) GIS database layers were read into Argus ONE and exported in a format for MODFLOW. In particular, the hydrography layer, which will outline the location of the river, lakes, and ponds, was exported. The DEM files were combined, rasterized, and brought into Surfer for additional analysis. ArcView allowed the files to be generated to resolutions that matched the proposed grid size of the model (300 m x 300 m). The DEM file is important for this model because it will determine the initial head of the system, locations of surface drains and elevations of surface water bodies as determined in the hydrography layer.
2) Argus ONE was used to set up the grid for the model. The initial cell size was set to be 300 m by 300 m. This initial size was chosen to maximize model output while retaining model resolution. The size of the cells may change depending on model results, model run-time, and resolution issues.
3) Because 3 various programs are being used to work with the data (Surfer, Excel, and MODFLOW), a FORTRAN program that will allow for data manipulation was written. The program will change the formats from each output to a form that can be read by the various programs. This will allow for maximum efficiency in data analysis. For instance, recorded model heads for each particular time step can be visually monitored in Surfer to watch as the head changes with time. If problems are noted in particular areas, more efforts can be focused on what physical or model issues are occurring.

Students Supported

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Papers and Presentations

None to date.